A Mechanistic Investigation of Nitrogen Evolution and Corrosion with OxyCombustion

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Objectives

Nitrogen evolution and corrosion potential will be investigated in oxy-fuel combustion conditions for three coals: Powder River Basin (PRB), sub-bituminous, Illinois 6, and Pittsburgh 8, bituminous. A flat flame burner will be used to study nitrogen evolution in coal particle stream devolatilization experiments at elevated temperatures produced by high oxygen content flames. A laminar flow reactor burning coal in CO_2/oxygen streams will be used to collect NO_x and temperature axial profiles as well as ash deposits to evaluate the effects on NO_x formation and corrosion potential.

Work To Date

Three coals have been selected, prepared and analyzed. Key features of the coals based on lab analysis are listed in Table 1. These coals have various amounts of sulfur and chlorine, corrosive elements, which will be measured in deposits formed after burning in various oxycombustion environments.

Coal Type	Moisture (%)	Nitrogen (%) (maf)	Sulfur (%) (maf)	Chlorine (%) (maf)	Ash (%) (mf)	HV (maf) (kJ/kg)
PRB (Caballo)	33.86	1.49	0.33	0.001	7.61	29,100
Illinois #6	14.22	1.27	4.64	0.134	9.31	33,090
Pittsburgh #8	2.57	1.38	3.86	0.064	10.67	34,390

A flat-flame burner and entrained flow reactor have been converted for simulated oxy-fuel combustion by using tanks of CO_2 and O_2. A schematic diagram of the entrained multi-fuel flow reactor (MFR) is shown in Figure 1. Both the CO_2 and O_2 gases experience cooling when expanded to lower pressure. The CO_2 has been found to require heating before the flow is measured and used in the combustion chamber. Gas and fuel flow rates have been calibrated and initial testing of the system has begun.

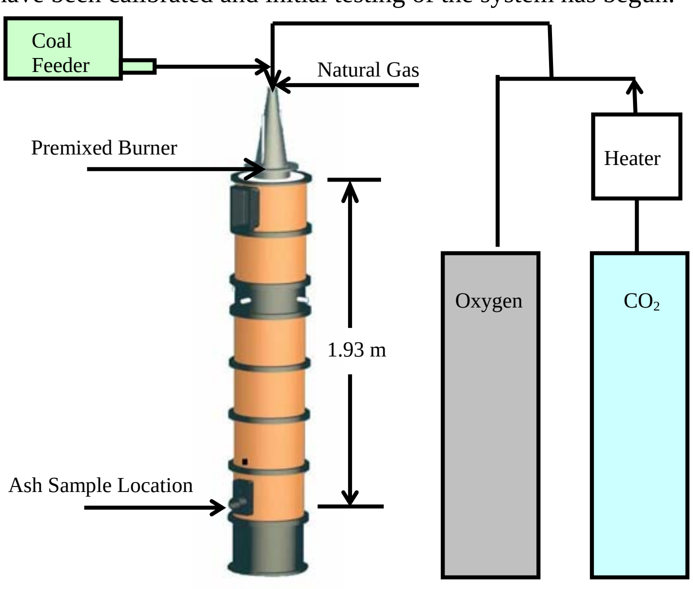

Figure 1. The muti-fuel reactor configured to run on simulated oxy-fuel combustion

Initial work on the flat-flame burner has also begun. Flames at elevated temperatures with higher heating rates have been produced as would be the case in some oxy-fuel conditions. A measurement of the axial or temporal temperature profile for one of the selected conditions is shown in Figure 2. The temperature along the axis of the fuel is cooler near the burner because of the primary gas which enters with the coal particles. The temperature 0.5 cm off axis is higher and represents the surrounding temperature produced by the flame. Peak temperatures above 1800 K are seen in the flame.

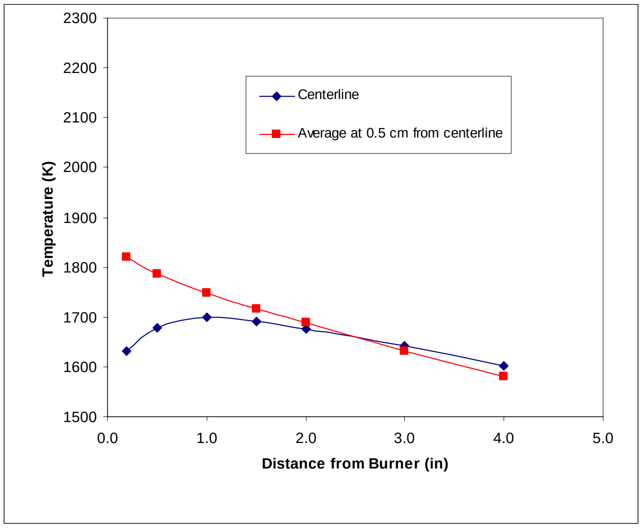

Figure 2. Measured temperature profiles in the flat-flame burner

Future Work

Several experiments on the FFB and MFR are planned which will identify the evolution of nitrogen and changes in corrosion potential. These experiments are too numerous to detail here but one will be described as an example.

A set of data will be collected measuring axial NO and temperature as a function of recycle ratio or CO_2 to O_2 ratio at a fixed fuel/O_2 ratio. Anticipated results are shown in Figure 3. Oxy-fuel combustion is expected to produce lower NO emission than air which will be measured as a baseline. As CO_2 concentration is increased, the temperature in the combustion zone should decrease producing a lower conversion of nitrogen to NO. Thus a trend of decreasing NO with increasing recycle ratio is expected. As NO is added to the inlet, the NO after the flame is expected to increase but perhaps not as high as the amount added because some of the NO may be destroyed as it passes through the flame. This experiments should provide evidence of the potential of the flame to reduce NO recycled in the flue gas as well as the influence of temperature on NO formation in an OxyCombustion flame.

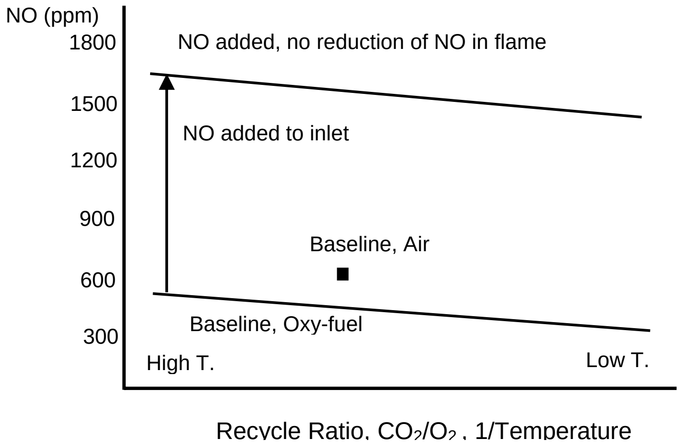

Figure 3. Anticipated results for NO as a function of recycle ratio with and without NO added to the inlet oxidizer.